## 4.14 Storm Drain Outlet Protection

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### Definition

Paved and/or riprapped channel sections placed below storm drain outlets.

### Purpose

Channel sections are used to reduce velocity of flow before entering receiving channels below storm drain outlets.

### Conditions

This standard applies to all storm drain outlets, road culverts, paved channel outlets, etc., discharging into natural or constructed channels. Analysis and/or treatment will extend from the end of the conduit, channel, or structure to the point of entry into an existing stream or publicly maintained drainage system. Professional engineering assistance is recommended.

### Design Criteria

Structurally lined aprons at the outlets of pipes and paved channel sections shall be designed according to the following criteria:

Capacity

Peak storm flow from the 10-year, 24-hour frequency storm or the storm specified code or the design discharge of the water conveyance structure, whichever is greater.

Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's equation may be used to determine tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a minimum tailwater condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a maximum tailwater condition. Pipes that outlet onto flat areas with no defined channel may be assumed to have a minimum tailwater condition.

### Apron Length and Thickness

The apron length and $d_{50}$, stone median size, shall be determined from accepted empirical tailwater conditions, stone size, pipe size, and discharge rate. A maximum stone size at 1.5 x $d_{50}$ may be assumed and an apron thickness of 1.5 x $d_{max}$ may be used.

Calculations, curve data, and source are to be provided.

### Apron Width

If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank, whichever is less. If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

1. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

2. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to three pipe diameters plus the length of the apron.

3. For a Maximum Tailwater Condition, the downstream end shall have a width equal to three pipe diameters plus 0.4 times the length of the apron.

### Bottom Grade

The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

### Side Slope

If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal:vertical).

### Alignment

The apron shall be located so that there are no bends in the horizontal alignment.

### Materials

The apron may be lined with riprap, grouted riprap, or concrete. The gradation, quality, and placement of riprap shall conform to applicable construction specifications.

Alternative structures for achieving energy dissipation at an outlet may be submitted for approval.

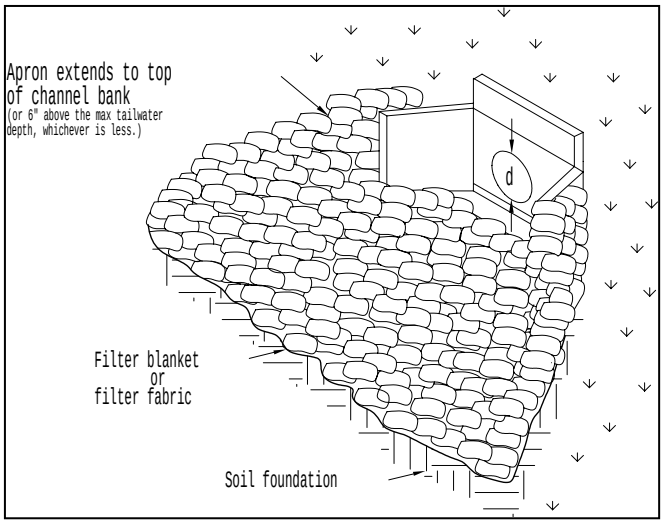


Figure 17.1 Outlet Protection for a Well-Defined Channel

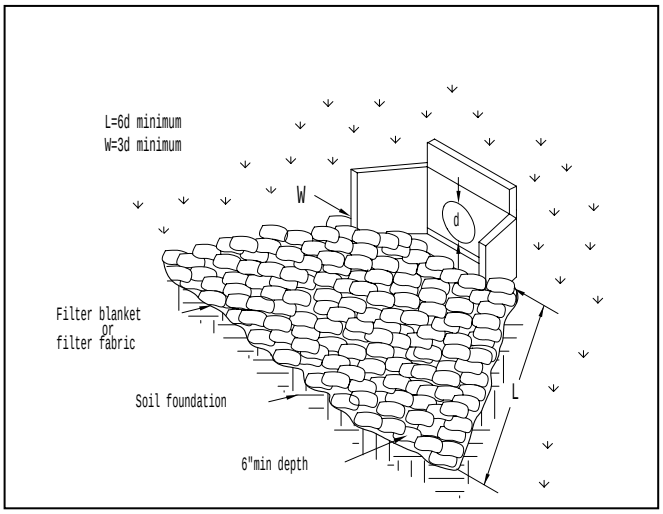


Figure 17.2 Outlet Protection for a Flat Area

**Construction Specifications**

1. Ensure that the subgrade for the filter and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.

2. The riprap and gravel filter must conform to the specified grading limits shown on the plans.

3. When used, filter fabric must meet design requirements and be properly protected from puncturing or tearing during installation. Repair any damage by removing the riprap and placing another piece of filter fabric over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive, replace the entire filter fabric.

4. Riprap may be placed by equipment but care should be taken to avoid damaging the filter.

5. The minimum thickness of the riprap should be 1.5 times the maximum stone diameter.

6. Construct the apron on zero grade with no overfall at the end. Level the top of the riprap at the downstream end with the receiving area or slightly below it.

7. Ensure that the apron is properly aligned with the receiving stream and preferably straight throughout its length. If a curve is needed to fit site conditions, it should be located in the upper section of the apron.

8. Immediately after construction, stabilize all disturbed areas with vegetation.

9. Select stone for riprap from field stone or quarry stone. The stone should be hard, angular, and highly weather resistant. The specific gravity of the individual stones should be at least 2.5.

10. Install a filter to prevent soil movement through the openings in the riprap. The filter should consist of a graded gravel layer or a synthetic filter cloth.

**Maintenance**

Inspect riprap outlet structures after heavy rains to determine if erosion has occurred around or below the riprap or if stones have been dislodged. Make needed repairs immediately to prevent further damage.